EXCHANGER OF THERMAL ENERGY WITH MULTIPLE CORES AND A THERMAL BARRIER

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to a multiple core exchanger of thermal energy having corrugated fins that are provided with a thermal barrier comprising a longitudinal slit formed without removal of material for impeding the flow of heat thereacross and bridges that locally connect material across the slit for promoting stability during construction of the heat exchanger and in service.

2. Background Art

In the field of exchangers of thermal energy, and more particularly of heat exchangers, louvers deflect or direct a fluid such as air and channel heat or coldness from a source. In older designs, little turbulation actually occurs, and laminar flow is relatively uninterrupted. Over the years, a louvered serpentine fin in heat exchangers has undergone design changes to optimize its contribution to the process of exchanging heat between, for example, a radiator and a condenser in the automotive field. Louver width has varied, as has its angle. Louver length has increased, bend radii have changed, and louver patterns have been experimented with in continued efforts to improve the efficiency of the heat exchange process.

It is known that the more the heating or cooling media can be turbulated, the more efficient the exchanger of thermal energy. One reason is the disturbance of boundary layers of stagnant media from which little thermal energy can be extracted. One approach is disclosed in commonly owned USPN 5,738,169, which is incorporated by reference herein.

A related need in the ideal turbulating louver is structural strength. But to realize manufacturing economics, the heat exchange industry has reduced the thickness of its fin material.

USPN 6,213,196 discloses a double heat exchanger that combines a condenser of a refrigeration cycle for a vehicle air conditioner and a radiator for cooling engine coolant. That patent is incorporated herein by reference. The reference teaches that in double heat exchangers, plural condenser tubes and plural radiator tubes can be arranged in a vertical direction at the same pitch. The height of each of the radiator tubes is larger than that of the condenser tubes in the vertical direction. Accordingly, the height of the condenser fin disposed between adjacent condenser tubes needs to be larger than that of the radiator fin disposed between adjacent radiator tubes in the vertical direction. '196 patent, col. 1, ll. 20-34. That reference teaches also that the heights of the fins associated with the first and second heat exchangers differ. *Id.*, col. 2, ll. 31-33.

It is known that dual-purpose fins exist in which slots have been introduced into the fin strip in order to inhibit heat transfer. Such slots require the removal of material from the fin strip before fin formation can be completed. Slug removal requires an additional operation and creates problems which include the expense of additional machinery and decreased fin speed production. There is also the possibility that if a blanking process is coupled with the fin-forming process, a slug of scrap material could find its way into the fin roll and damage it, or jam the fin-forming machine. Additionally, the unwanted presence of such debris could adversely interfere with the brazing or core-building process.

Following conventional teachings (such as those disclosed in the '196 patent), each heat exchanger in a double exchanger configuration is brazed before assembly. The thermal break between the condenser and radiator is defined by mechanical brackets so that contact is avoided between the heat exchanger surfaces of the fin and the tube of the condenser and radiator heat exchangers.

In summary, contemporary automotive radiators and condensers are being combined by mechanical assembly and mounted in vehicles. Fabrication and manufacturing costs are significant.

SUMMARY OF THE INVENTION

In light of such prior art approaches, it would be desirable to manufacture in a single assembly that which was previously available only as two or more assemblies. More specifically, it would be desirable to produce a multi purpose exchanger of thermal energy (e.g. a condenser/radiator combination) by brazing the assembly as a single unit which by design would allow for independent functionality of the radiator and condenser systems.

Accordingly, the disclosed invention calls for a fin that includes a radiator fin and a condenser fin (in the case of a condenser/radiator assembly) that are separated by a thermal break. In order for the thermal break to be effective, it is integrated with other components of the heat exchanger assembly: headers, side supports, and channels or flattened tubes.

The cores of the disclosed invention have one or more fins interposed between the channels and the manifolds. The fins are separated from each other by a thermal barrier comprising a slit which is formed without removal of material. The slit inhibits the flow of heat energy across the width of the strip. At least some of the fins include louvers defined within the strip of which the fins are constructed. The louvers extend transversely partially across a given elongated strip. The louvers are configured in a plurality of arrays, the arrays being situated adjacent each other across the elongated strip.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1(a) is a perspective view of an exchanger of thermal energy through which a cooling medium (such as ambient air) passes;

FIGURE 1(b) is a sectional view in the plane 1b-1b of FIGURE 1(a), illustrating a multiple core heat exchanger made according to the present invention;

FIGURE 1(c) is a top plan view of a flattened fin which illustrates a thermal break between adjacent fins and bridges of material continuity (thermal fuses) extending between adjacent edges of the fins;

FIGURE 1(d) is a quartering perspective view of a serpentine form of fin made according to the present invention;

FIGURES 2(a)-(f) are more detailed sections of a fin of the subject invention;

FIGURE 3 illustrates the locations of thermal fuses in the fin of the subject invention;

FIGURE 4 is an assembly drawing of a fin roll which, in one alternative method, is used to manufacture the fin of the present invention;

FIGURE 5 is a sectional view taken along the line 5-5 in FIGURE 4;

FIGURES 6(a)-(e) are side elevational views of cutting blades that are assembled into a fin-forming roll that illustrate the geometry which forms the louvered and non-louvered surfaces of the serpentine fin;

FIGURES 7(a)-(c) depict blade tooth forms which when rolled in the locations shown in FIGURE 5, create slits along the length of the fin, which form the thermal break in section 2e-2e (FIGURE 2(a)); and

FIGURE 8 illustrates alternative embodiments of the thermal fuses of the subject invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIGURE 1(a) illustrates one embodiment of the disclosed exchanger of thermal energy: a heat exchanger 10 for a vehicle. The exchanger of thermal energy has a core providing fluid passages through which, for example, a coolant (such as water) flows through a radiator while in cooling a water-cooled engine. A core portion of a condenser 12 is illustrated in FIGURE 1(b). It provides fluid passages through which a refrigerant circulates in a refrigeration cycle. Conventionally, the temperature of the refrigerant is lower than that of the coolant. Accordingly, the core portion of the condenser is typically oriented on the air upstream side of the core portion of the radiator.

FIGURE 1(a) depicts a exchanger of thermal energy 10 (such as, but not limited to a condenser) through which a cooling medium such as air passes. The heat exchanger 10 includes such features as channels or flattened tubes 14 that extend transversely between spatially separated manifolds or headers. Fins 16 (preferably, but not necessarily in convoluted or serpentine form) are inserted between and fused to the fluid-carrying transverse channels 14 to facilitate the heat exchange between a fluid flowing in the channels and the cooling medium, such as ambient air. Once assembled, the manifolds, the channels, and fins are fused to each other to form an integral, fluid-tight assembly. The exchanger of thermal energy 10 may be used as a radiator, oil cooler, transmission cooler, charge air cooler, condenser, evaporator, heater or any other type of heat exchange assembly.

FIGURE 1(b) is a cross-sectional view taken along the line 1b-1b of FIGURE 1(a). A first core 12 is, for example, a condenser that is placed on the upwind side of the multiple core exchanger of thermal energy 10. A second exchanger of thermal energy 30 (such as, but not limited to a radiator) is juxtaposed therewith. Both cores 12, 24 are disposed between the side manifolds shown in FIGURE 1(a).

The first core 12 has a plurality of first channels 14 through which a first fluid flows and a first fin 16 that is disposed, preferably in a convoluted manner, between adjacent first channels 14 to facilitate heat exchange between the first fluid and the cooling medium.

On the right hand side of FIGURE 1(b), a second core 30 (such as a radiator) is disposed downstream of the first core 12. The second core 30 has a plurality of second channels 32 through which a second fluid flows. A second fin 34 is disposed between adjacent second channels 32 to facilitate heat exchange between the second fluid and the cooling medium. The second channels 32 extend substantially parallel with the first channels 14.

Turning now to FIGURES 1(c) - (d), there are depicted top and quartering views of a flattened strip of pre-corrugated material that has been flattened for visualization (FIGURE 1 (c)) and after it is corrugated into a serpentine fin configuration (FIGURE 1(d)). As best seen in FIGURE 1(d), the first fin 16 has first upper folds 18, first lower folds 20 and first walls 22 extending between one of the first upper folds and one of the first lower folds. Optionally, a first array of louvers 24 extends from the first wall 22.

The second fin 34 (FIGURE 1(d)) is integrally formed with the first fin 16. Thus, the second fin 34 also has a corrugated shape defined by second upper folds 36, second lower folds 38 and second walls 40 that connect one of the second upper folds 36 and one of the second lower folds 38. Optionally, a second array of louvers 42 extends from the second wall 40.

A thermal break comprising a slit 50 (FIGURES 1(c) -(d)) is formed without removal of material between the first and second upper and lower folds, and the first and second walls. The slit 50 insulates heat conductivity between the first and second fins, and may be of uniform or non-uniform length.

As best illustrated in FIGURE 1(c), one or more thermal fuses or bridges 52 locally connect the first and second fins. Optionally, the thermal fuses 52 may or may not be broken after brazing. Such a selective activation function permits the designer to promote structural integrity during pre-braze assembly and enable a localized transfer of heat. It will be appreciated that such fusing can be fabricated from heavy-gauge or light-gauge material so that they may respectively retain mechanical integrity and positioning, or be readily degradable.

Continuing with reference primarily to FIGURE 1(c), the first and second fins 16, 34 comprise an elongated strip 60 having a pair of opposing edges 62, 64, an upper 66 and a lower face 68 (FIGURE 1(d)) and (optionally) at least one louver 70 defined within the strip so that no material of which the strip is formed is removed during formation of the at least one louver. As illustrated in FIGURES 1(c)- 1(d), the at least one louver extends transversely at least partially across the elongated strip, either inclined or orthogonally to its edges.

As best shown in FIGURE 1(c) the thermal fuse 52 is formed between adjacent edges 64 of the first and second fins 16, 34. Each thermal fuse 52 comprises a portion of material continuity extending between the first and second fins 16, 34 for promoting stability during construction of the exchanger of thermal energy.

Since it is undesirable to have the heat exchange surfaces of the condenser and radiator in physical contact in one embodiment, the thermal fuse can be eliminated following mechanical assembly by subsequent degradation during the brazing process or by other means, such as chemical dissolution by an active flux during controlled atmosphere brazing. The consequent reduction in the number of thermal fuses serves to further isolate the radiator and condenser forms of exchangers of thermal energy. Thus, the thermal fuse 52 fulfills the dual role of adding strength during assembly while degrading fin junctions during operation.

Continuing with primary reference to FIGURE 1(c), the first fin has a width (L_1), and the second fin has a width (L_2). Preferably, but not necessarily, L_1 is less than or equal to L_2 where the first and second heat exchangers are respectively a condenser and a radiator.

Turning now to FIGURES 2(a)-(f), there are depicted other views of the thermal break comprising a slit 50 and a thermal fuse 52 (FIGURE 2(e)) between condenser and radiator fins. In FIGURE 2(b), the slit 50 is shown with displaced opposing edges, thereby creating one form of the thermal break. In the example shown in FIGURE 3, the thermal fuse appears once every 6.5 convolutions. FIGURES 2(c)-(f) are sectional views taken along the respective sectional lines illustrated in FIGURE 2(a). FIGURE 2(c) illustrates a configuration wherein the first fin 16 has one array of louvers extending between the edges thereof. FIGURE 2(e) illustrates a configuration wherein the louver (in the example shown, of the second core 34) are split. FIGURE 2(e) illustrates fin separation and the slit 50 formed between the first and second upper and lower folds, and the first and second walls. For comparison, FIGURE 2(f) illustrates a neutral surface of either fin.

Turning now to FIGURE 3, there is depicted a side elevational view of a fin which is illustrative of that which may be associated with either the first or the second cores 12,30. It should be understood that the thermal fuse 52 can be located on the upper folds 18, 36 respectively of the first or second fins 16, 34, or the lower folds 20, 38. In one embodiment, the thermal fuses 52 are located once every 6 and one-half convolutions. As illustrated, the thermal fuse 52 is located alternatively from top to bottom, but need not be so located.

The slits 50 and thermal fuses 52 can be manufactured by such techniques as laser cutting, plasma cutting, water jet cutting, or other similar processes. Preferably, to form the fin depicted in FIGURE 3, a fin forming roll produces 4 such thermal fuses during each revolution of the fin roll. The minimum number possible is one thermal fuse per revolution of the fin roll, which could exist either on the top of the fin or the bottom of the fin. The number of thermal fuses cannot exceed the number of teeth on the fin roll. Equal spacing between the

thermal fuses is not a requirement. Irregular spacing is enabled by using such techniques as laser cutting, plasma cutting, or water jet cutting.

Turning now to FIGURE 4, there is depicted an assembly drawing of a fin roll which creates a fin with a plurality of thermal fuses. The reference numerals 12, 30, and 50 respectively indicate the locations on the fin roll that form the first and second fins 16, 34 and the thermal break 50.

FIGURE 5, is a sectional view taken along the line 5-5 of FIGURE 4, illustrates the locations of each blade in the fin roll which create a specific part feature, e.g. louvered and non-louvered areas. The thermal break is created at fin blade locations) locations 80, 82. The blades on the left hand side of FIGURE 5 form the first core (e.g. condenser). The blades on the right hand side of FIGURE 5 form the second core (e.g. radiator).

FIGURES 6(a)-(e), illustrate the shapes of teeth in a fin roll that form the louvered and non-louvered surfaces of the fin. An appreciation of the surfaces and shapes is helpful in visualizing the different louver patterns formed by the blades depicted in FIGURES 4-5. FIGURE 6(a) depicts a blade which is used to form a border 90 (FIGURE 5). FIGURE 6(b) shows the blade form used in sections 94, 96 of the fin roll (FIGURE 5). FIGURE 6(c) illustrates the form of blade which is used at 98, 100 of the fin roll illustrated in FIGURE 5. FIGURE 6(d) illustrates a cutting blade on which the shapes of the teeth create different louver patterns. FIGURE 6(e) illustrates the blade form that occupies positions 102, 104 of the fin roll in FIGURE 5.

FIGURE 7(a)-(c), respectively illustrate the crotch areas of blades used in the fin forming roll. The normal crotch areas are depicted by the reference numeral 110 in FIGURE 7(a). The altered crotch 112 creates two locations at which there is a thermal fuse 52 at location 80. FIGURE 7(b) illustrates a blade configuration at locations 82 (FIGURE 5). In FIGURE 7(b), the exaggerated tooth form 114 is at location 82 (FIGURE 5). In FIGURE 7(c), the special crotches 112

(FIGURE 7(a) are shown in relation to the overall circumference of the fin roll at locations 116.

Thus, FIGURES 7(a)-(b) illustrate the blade forms which when rolled in the proper locations defined in FIGURE 5 create a continuous slit 50 along the length of the blade edge form. The slit continues to be formed until a specially designed area of the form is encountered in the shape of an altered crotch 112 (FIGURE 7(a)). This area is designed to allow the radiator side of the fin, for example, to be joined with the condenser side of the fin. It should be realized that the altered area to create a thermal fuse need not reside at the crest of a convolution or bend radius. It can exist anywhere on the flank of a tooth.

Preferably, the thermal fuse 52 is located on a wall of a fin, approximately midway between two adjacent bend radii. Such a configuration orients the thermal break in the midair wall of the core. Thus, using the disclosed fin roll, the location of the thermal fuse is predicted, as opposed to being randomly placed by an additional operation.

As mentioned above, the thermal fuse 52 eliminates or reduces the number of thermal junctions, so that heat transfer characteristics in the combined exchanger of thermal energy are improved. To improve the isolation between the radiator and condenser, the thermal fuse 52 provides mechanical support during assembly and may optionally subsequently be degraded or eliminated during the brazing process. The thermal fuse contemplates that the morphology of the junctions may be small and can be removed by chemical dissolution using an effective flux during controlled atmosphere brazing and/or thermal degradation. This results in a reduction in the number of thermal junctions and serves to further isolate the cores in the exchanger of thermal energy.

FIGURE 8 illustrates an enlargement of the area in FIGURE 1(c) depicted by the reference numeral 52 and shows alternative thermal fuse morphology. In FIGURE 8(a), the thermal fuse is generally rectangular or square with sides depicted as X and Y. In FIGURE 8(a), preferably, the length of segment

X (where X$\geq$zero at the thermal break) is less than or equal to that of segment Y. In FIGURE 8(b) the thermal fuse is formed by two curvilinear arcuate sections. In both FIGURES 8(a) and 8(b), the thermal fuse is made of a homogeneous material. In FIGURE 8(c), the thermal fuse includes cavities or areas of material discontinuity. It will be appreciated that any combination of these configurations may be effective in use.

While embodiments of the invention have been illustrated and described, it is not intended that these embodiments illustrate and describe all possible forms of the invention. Rather, the words used in the specification are words of description rather than limitation, and it is understood that various changes may be made without departing from the spirit and scope of the invention.